Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Satellite Delivery of Network Signals to Unserved Households for Purposes of the Satellite Home Viewer Act	)	CS Docket No. 98-201 RM No. 9335 RM No. 9345
	)	
Part 73 Definition and Measurement of Signals of Grade B Intensity	)	

DECLARATION OF WILLIAM H. HASSINGER

I, William H. Hassinger, hereby depose and say as follows:

1. I am submitting this declaration in support of the comments filed in this matter by PrimeTime 24 Joint Venture ("PrimeTime 24"). The opinions and statements set forth herein are based on: my experience in the development and oversight of engineering policy and rulemaking in television and radio broadcasting for the Federal Communications Commission, including matters involving the Commission's rules regarding field strength contours and measurements; my review of the technical literature and history of the development of the field strength contours; my review of the Satellite Home Viewer Act of 1988, as amended (the "Act" or "SHVA"); and my general training, education, and experience.

2. I hold the degrees of Bachelor of Science with a major in Economics from the University of Wisconsin, Madison, Wisconsin, and Master of Science in Electrical Engineering from the U.S. Naval Postgraduate School, Monterey, California.

3. I was employed as an electronics engineer for nearly 23 years with the Federal Communications Commission. From January 1980 to April 1987 I was the Engineering Assistant

to the Chief of the Mass Media Bureau. From April 1987 until my retirement in September 1995, I was the Assistant Bureau Chief (for Engineering) of the Mass Media Bureau.

4. My opinions and statements set forth herein may be summarized as follows:

- The Commission has never defined a "signal of grade B intensity" as received "through the use of a conventional outdoor rooftop receiving antenna." Accordingly the Commission needs to adopt a new standard, rather than modify an existing one.

- The Commission should define a "signal of grade B intensity" as received "through the use of a conventional outdoor rooftop receiving antenna" as a one which is adequate to produce a picture acceptable to the median viewer when the viewer employs a conventional rooftop antenna.

- This standard should include field strength values, which must be increased from the grade B contour values developed in the early 1950s for predicting the general service area of stations. Specifically, those values should be at least 67 dBu for low VHF, 72 dBu for high VHF, and 81 dBu for UHF for the field strength at a household. These values have been developed by updating certain key planning factors and by reference to an empirical study of relationship between picture quality and signal strength.

- The "grade B" standard for SHVA purposes should also take into account circumstances when a household cannot receive an acceptable quality picture because of interference from other stations, ghosting, and other factors, even if the requisite signal strength is present.

- The Commission should adopt a methodology for predicting whether a household is likely to receive the requisite signal, and a procedure for resolving contesting cases.

I. The Commission Has Never Defined a "Grade B Intensity Signal" As Received Through the Use of a "Conventional Outdoor Rooftop Receiving Antenna".

5. The SHVA defines an "unserved household," with respect to a particular television network, as a household that:

> cannot receive, through the use of a conventional outdoor rooftop receiving antenna, an over-the-air signal of grade B intensity (as defined by the Federal Communications Commission) of a primary network station affiliated with that network. . . .

17 U.S.C. § 119(d)(10).

6. The Commission has never defined an "over-the-air signal of Grade B intensity" as received through the use of "a conventional outdoor rooftop receiving antenna." What the Commission defined in 47 C.F.R. § 73.683 are the Grade A and Grade B field strength contours. Along each contour the expected signal strength is not constant but varies with time and location.

7. The pertinent sentence says, "The required field strength, F(50,50) ... for the Grade A and Grade B contours are as follows: [this is followed by a table of values]". The expression F(50,50) is critical and inseparable from the numbers in the table. The meaning is as follows (using, as an example, Channels 7-13, Grade B, 56 dBu). The Grade B contour of a Channel 7-13 station is the contour completely surrounding the station, along which the field strength of the station's signal at the best 50% of locations should exceed 56 dBu 50% of the time. Hence the expression F(50,50); the "F" is of no significance. The method for determining the location of the Grade B (and Grade A) contour is described in 47 C.F.R. section 73.684 (which also explains the meaning of F(50,50)). Neither the definition nor the method enable one to identify which locations are the best 50%, or what the instantaneous or average signal should be at any particular location. Further, if one measures a signal of 56 dBu at a particular location, one cannot tell from that information alone whether the measurement site is on, inside or outside the Grade B contour, or what value one could expect when repeating the measurement at some other time.

8. What the Commission defines in section 73.683 is the statistical property of a contour, not the intensity of a signal. An analogy may help to clarify this. Let us define an efficient highway as one on which the S(50,50) vehicle speed is 65 mph. That is, looking at the highway as

a whole, the median speed is 65 mph. On the fastest sections of the highway (totalling 50% of the overall length) the average vehicle speed will be greater than 65 mph. On the slowest sections, it will be less. Note that from the S(50,50) specification, one cannot identify the fast and slow sections or conclude anything about any single vehicle's speed. S(50,50) does not define the efficient speed of a vehicle but rather the behavior of many vehicles on an efficient highway. Similarly, the F(50,50) specification does not define the strength of a single television signal, but rather, the long term behavior of many signals along a contour.

9. The purpose of the Grade A and Grade B contours is given in Section 73.683(a). The contours indicate the approximate extent of coverage over average terrain in the absence of interference from other television stations. Under actual conditions, the true coverage may vary greatly from these estimates (because of terrain). Further, section 73.683(c) states that the field strength contours will only be considered in certain matters related to broad area coverage. This precludes the contours from being used for determinations of individual household eligibility under SHVA.

10. The matter of the Grade A and Grade B contours was addressed by the Commission in 1975 in its Report and Order on field strength curves for TV and FM.[1] In it the Commission stated that the Grade A and Grade B contours were intended to have only nominal significance (para. 59) and are primarily administrative tools (para 61). They enable the Commission and a licensee to predict, in a rough manner, the area within which a station will likely draw its audience. The curves

[1]Report and Order in the Matter of Amendment of Sections 73.333 and 73.699; Field Strength Curves for FM and TV Broadcast Stations; Amendment of Part 73 of the Rules Regarding Field Strength Measurements for FM and TV Broadcast Stations ("Field Strength Measurements"), 53 F.C.C. 2d 855 (1975).

do not define where service begins and ends. There will be locations outside a Grade B contour that receive service, and locations inside the contour that do not. The F(50,50) values are useful in predicting broad area coverage, and not service to individual households.

11. The foregoing analysis is intended to show that a "signal of Grade B intensity" has not been defined nor is it inflexibly linked to the specifications of a regulatory tool (the Grade B contour). In this proceeding the Commission is free to determine how best to define such a signal without disturbing the definition of the existing, well-established Grade B contour, and without affecting the various rules, policies and decisions which rely on that contour. A proposal for defining a signal of Grade B intensity is discussed below.

II. Defining a "Grade B Intensity Signal" Received Through a Conventional Outdoor Rooftop Receiving Antenna

12. From the language of the SHVA (and as the courts have noted) it appears that Congress wanted a reasonably identifiable measure by which to judge whether one individual household is served or not. By focusing on an individual household, rather than a community or area, Congress clearly intended that determinations of service (or lack thereof) be resolved on a case-by-case basis. Further Congress wanted this measure to include, at least in part, some value of signal strength. The inclusion of "cannot receive" and "conventional antenna" indicate that factors other than signal strength should be considered.

13. It is plain that Congress considered service more than just some value of electromagnetic radiation. If Congress were solely concerned with the presence or absence of a television signal of a given strength, then the phrase "cannot receive, through the use of a conventional outdoor rooftop antenna" is superfluous and even confusing. That is, if the test is

simply a specified signal at some standard height above ground near a household, the presence of such a signal would satisfy the test and receivability is moot. However, "cannot receive" encompasses more than the mere presence or absence of a signal and requires consideration of such factors as:

(i) Stability and reliability of the desired signal (TV signals exhibit long and short term variability)

(ii) Interference by undesired signals

(iii) Electrical noise

(iv) Legal restrictions on antennas

(v) Antenna orientation (not all TV signals arrive from one direction)

(vi) Ghosting (multipath)[2]

14. The references to signal measurements in the SHVA also imply that Congress was under the impression that signal strength measurements are repeatable (confirmable), simple, inexpensive and relevant. These qualities tend to be mutually exclusive. The challenge is to devise an objective measure of service that satisfies the purpose of the SHVA, lends itself to economical implementation, and - we hope - is intelligible to the general public. An approach that employs several levels or stages of evaluation appears consistent with the SHVA. Combining a proxy technique for an initial determination of service, with individual assessments to resolve contested cases, may help to minimize disputes and reduce implementation costs.

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[2] With respect to this last factor, the Commission's Interference Handbook (Bulletin CIB-2, May 1995) says, on page 6, "Double images of a TV program, or 'ghosting', is a common problem with off-air TV reception in urban areas." While ghosting and the other problems noted above can often be dealt with, the resulting service may be less than satisfactory. Picture quality may be degraded, station choices may be limited, or households may have to install large, expensive rotating (i.e. "unconventional") antennas.

15. In the Sixth Report and Order in Dockets 8736, 8975, 9175 and 8976, adopted April 11, 1952, the Commission chose basic technical standards for the television service. In that proceeding the Commission employed the concept of a standard criterion of service, which is the availability of a desired signal, free of interference, for at least 90% of the time. For both Grade A and Grade B the desired signal was one thought to provide a picture whose quality was "acceptable" to the median viewer. For Grade A service those conditions must be met for the best 70% of receiving locations at the outer limits of this service. For Grade B service those conditions must be met for the best 50% of receiving locations at the outer limits of this service. The distinction between Grade A and Grade B service is not in the quality of the picture (Grade A is not better than Grade B) but in the probability (70% versus 50%) of receiving a picture of the same (acceptable) quality, given various assumptions about household receiving systems and ambient noise.

16. Two criteria account for most of the differences in the F(50,50) signal strength used to define the Grade A and Grade B contours. The Grade B contour assumes a noise-free environment and the use of an antenna (probably on the rooftop) that is better than a simple dipole (a very basic antenna). The Grade A contour assumes an electrically noisy environment but an antenna no better than a dipole. The foregoing discussion suggests that a generic definition of a grade B intensity signal received through the use of a conventional rooftop antenna may take the following form:

> A signal of grade B intensity is one which is adequate to produce a picture acceptable to the median viewer, when the viewer employs a conventional rooftop antenna.

17. The next task is to attach concrete signal strength values to that definition. Two approaches are discussed below -- "building block" and "empirical". In the first, use is made of

planning factors in a manner similar to what was done in developing the Grade A and Grade B contours.[3] The "building block" technique has some merit because it permits the independent evaluation of each separate factor. The disadvantages to this technique are: (1) we may not know or be able to agree on the values to assign to the factors, and (2) we may have omitted one or more factors whose effects overwhelm everything else.

18. In the empirical approach, use is made of a study which directly compared field strength measurements with picture quality on a site-by-site basis. This permits a simple signal vs quality correlation under actual conditions experienced by households. In practice the study may over- predict the availability and quality of reception simply because, compared to household systems, the test equipment was better maintained and the antenna alignment was optimized. The drawback to this approach is that various effects are lumped into one number and therefore one cannot determine why, for example, a low signal at one site produced a good picture whereas a higher signal at another site produced a poor picture.

A. Building Block Approach: Updating the Planning Factor for SHVA Purposes

19. Although the planning factors used in developing the Grade B contour are intended for use with predicting area coverage, it may be instructive to ask whether they are suitable for measured signals at fixed locations. That is, if the signals measured at a number of households were 47dBu (the low VHF, Grade B, F(50,50) value), would the picture be of acceptable quality? The

[3] The declaration that I submitted in the Miami litigation, which was submitted with PrimeTime 24's comments in support of the emergency petition for rulemaking of the National Rural Telecommunications Cooperative (RM-9335), discusses the genesis of the planning factors.

answer is probably not. In a study discussed below it is shown that when the measured signal strength is 47dBu, about 70% of the locations were shown to have an unacceptable picture.

20. The reason for this is that the planning factors specified for the Grade B contours do not account for ambient noise, interference, ghosting, realistic household receiving systems, and current viewer perceptions of quality. The question then is, can we add to or modify the planning factors and arrive at some useful numbers?

21. The C/N ratio in the television planning factors is 30dB. While that figure might have been thought adequate to produce a "passable" picture to the median observer in the early 1950's, it is plainly outdated today. For one thing, while 50% of the observers may have thought the picture was passable or better at that time, the other 50% did not. For another thing, the rating of "passable" was applied in the context of small black and white television sets and viewers who were undoubtedly less critical than they are in today's world of VCRs, large screen television sets, and heavy television watching. In the early 1950s viewers had no need to be able to read character-generator produced text (such as sports scores) or to be able to record programming on a VCR. A more appropriate C/N figure for today may be adopted from the cable television context. In modifying the Cable Television technical standards in 1992, the Commission adopted a C/N of 43dB. While the Commission was concerned with service to cable television subscribers in that proceeding, the Commission said, "we reiterate that there is merit to the criticism that our standards in this regard need to be improved in order to assure the provision of a high quality picture. . . " Report and Order, In the Matter of Cable Television Technical and Operational Requirements; Review of the Technical and Operational Requirements of Part 76, Cable Television, 7 FCC Rcd

2021, ¶ 37 (1992). It is both appropriate and timely to apply that policy to viewers who receive their television programs off the air.

Improving the C/N ratio from 30 dB to 43 dB would raise the Grade B values to:

	Noise Free
Low VHF	60dBu
High VHF	69dBu
UHF	77dBu

This upward adjustment more closely represents the level of quality that is or should be considered "acceptable" today. "Noise free" means no ambient noise or interference.

22. With respect to UHF, the planning factors allow 13 dBu for antenna gain. In the staff report on UHF Comparability, the staff suggests that a more reasonable figure is 9 dB. Making that correction would further raise the UHF noise-free Grade B level by 4 dB. This adjustment would give households more latitude in antenna selection while still requiring them to make a reasonable effort to receive a signal. (Even 9 dB may be too high if a "conventional rooftop antenna" is assumed to an all-band antenna.) This changes the foregoing values to:

Noise Free	
Low VHF	60 dBu
High VHF	69 dBu
UHF	81 dBu

23. In the technical literature external ambient noise is treated as an additional planning factor.[4] The differences between no ambient noise and urban noise is:

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[4] See Staff Report on Comparability for UHF Television at 249 (1980); Gary S. Kalagian, A review of the Technical Planning Factors for the VHF Television Service, FCC, Office of Chief Engineer, Bulletin RS77-01 at 11 (1977). Ambient noise can also be treated as an independent criterion that must be overcome to produce an acceptable quality signal . Signal (continued...)

Low VHF	+14 dB
High VHF	+ 7 dB
UHF	+ 0 dB

If we use half of those factors to account for ambient noise midway between the rural (no noise) and urban (noise/interference) extremes, we have:

	Noise Free	Correction	Noise/Interferencere
Low VHF	60 dBu	+7 dB	67 dBu
High VHF	69 dBu	+3 dB	72 dBu
UHF	81 dBu	+0 dB	81 dBu

24. The foregoing shows how contour values could be adapted to measurement values. The selected values are conservative. Other adjustments to the planning factors would likely raise the selected values. See Staff Report on Comparability for UHF Television at 247-252 (1980). For example, the antenna gain for the low VHF is probably optimistic. Id.. In addition, the time variability figure assumed in the original planning factors appears to be too low, as is the line loss. Id. Moreover, if a conventional receiving system is assumed to have a splitter (which is a reasonable assumption because most households have more than one television set and cannot be expected to have two rooftop antennas), then 3 dBu should be added. While the receiver noise figures assumed in the original planning factors may be pessimistic, id., on balance these other adjustments should raise the values from those suggested above. In any event, it is clear that the

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[4](...continued)
strength values needed to overcome urban noise and interference (in areas outside the principal city) can be obtained from the Third Further Notice (1951). If adjustments are made for a higher level of desired picture quality, we are lead to signal values that are close to, but higher than, the ones developed above. This approach has not been pursued further.

contour values must be increased significantly if they are to be meaningful for individual sites and to reflect more realistic picture quality standards.

B. An Empirical Approach

25. A study seeking to directly correlate picture quality with signal strength was conducted by Neil M. Smith, a broadcasting and telecommunications consultant, and presented at the National Association of Broadcasters Engineering Conference on March 30, 1971. While the study did not purport to be definitive, the results were, and are, useful.[5]

26. In the Smith study data were obtained on a low VHF, a high VHF and a UHF station serving the same area. 609 observations were taken at 203 locations, covering a wide range of field intensity and picture quality. The antenna was an all-channel type representative of the antennas being installed in that area. It was mounted on a telescoping mast to permit measurements at an antenna height of 30 feet above ground. Signal strengths were measured on two commercial field intensity meters and the pictures were observed and rated on a new black and white television set, using TASO grades based on the TASO studies conducted in the late 1950's.

27. Smith presents a summary of the data in Table 4 of his report by comparing measured field intensity to picture grades. It is immediately apparent that there is a wide spread in the data, and that the median values are appreciably higher than the F(50,50) Grade B values used by the Commission to estimate coverage. For example, if we look at TASO Picture Grade 3 (Passable) we find the following:

[5] A copy of the Smith study is attached hereto.

	Field Intensity (dBu)	
	Median	Range
Low Band VHF	59	38-77
High band VHF	69	58-97
UHF	75	58-88

In low band VHF (Channels 2-6), a field strength of 38dBu may be sufficient to produce a TASO Grade 3 picture at one location; at another 77dBu is necessary -- a range of 39 dB. The median value is 59 dBu. (The F(50,50) Grade B value is 47dBu). Similar results were found for all picture grades and all channels.[6]

28. Since one objective of this proceeding is to identify an appropriate value (actually one value for each TV band) of signal intensity that is suitable for individual households, the value should be at the higher end of the range in this table. For example a signal strength of 77dBu is indicated if the Commission wants to assure that all households can receive a TASO Grade 3 picture on low-band VHF. Even selection of a signal as low as the median value of 59 dBu (which is 12 dBu higher than the current standard) as the criterion would mean an error rate of 50% in determining the availability of service at individual households.

29. Smith also rearranged his data in what he described as an unorthodox manner but which suggests a feasible approach to selecting (and defining) a signal level of Grade B intensity for SHVA purposes.

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[6] The Smith data argue against the common notion that grade B contour values are equivalent to TASO 3 (passable). The data show that the grade B contour values are more closely associated with TASO 4 (marginal) or TASO 5 (inferior). This alone indicates that we need signal strength values much higher than the grade B contour values to assure acceptable service to households.

30. Figures 5-A, 5-B and 5-C in the Smith report relate field intensity, picture quality and percentage of locations. These can be used in several ways. In figure 5-A (low VHF) we find that with a measured field intensity of 60 dBu:

25% of locations receive Grade 1 quality
25% of locations receive Grade 2 quality
28% of locations receive Grade 3 quality
14% of locations receive Grade 4 quality
8% of locations receive Grade 5/6 quality

31. Alternatively, if we select some percentage, for example 90%, we find that a measured field intensity of 66 dBu is necessary for a Grade 3 or better picture at 90% of all locations receiving signals of that strength. This latter example illustrates a straight forward technique for selecting required field strength values.

32. Ninety percent is in appropriate criterion for choosing a proper field strength value for several reasons. For one, it offers assurance that measurements at households will correlate with picture quality at most of those households and gives more confidence in the reliability of single measurements.[7] For another, it results in higher values more appropriate to viewers' expectation of quality. The average viewer today is likely to equate "acceptable" service with Grade 2 or even Grade 1, rather than Grade 3 used in the early years of television. Moreover, the Smith study itself was conducted more than 25 years ago on small black and white television sets, before color television became ubiquitous and when there was less environmental noise than there is today.

[7] A one-time measurement at a single location (a household) may not give any assurance of long term service to that household. A measured value of, say, 60 dBu could have been obtained at a point where the long term variation ranges from 48 dBu to 60 dBu. This measurement would, therefore, have overstated the service available. To account for this problem, eligibility criteria based on one-time measurements should err on the side of higher field strength values.

33. Based on this discussion and using 90% to derive field strength values from Figures 5-A, 5-B and 5-C of the Smith study, we have the following:

	Signal of Grade B signal intensity For SHVA determinations
Low VHF	66 dBu
High VHF	68 dBu
UHF	83 dBu

34. While the foregoing relies on measurements in one area, there is no reason to believe that similar results would not be obtained in other areas. This was not a study of terrain and propagation effects, but of actual signals compared to perceived picture quality. Also, while there is some dispersion in the data, it is typical of studies of this type.[8] A new study, using a 27" color monitor, current standards of quality, and equipment characteristic of the conventional homeowner would likely show that these values are too low.

35. The results obtained above from the two approaches may now be compared:

	Signal of Grade B intensity For SHVA determinations	
	Building block	Empirical
Low VHF	67 dBu	66 dBu
High VHF	72 dBu	68 dBU
UHF	81 dBu	83 dBu

[8] The famous TASO picture quality studies -- which have served as a reference for four decades -- were done with a total of only 200 observers recruited from colleges and community organizations in the Princeton, New Jersey area. One test, which evaluated the effect of random noise interference, used only 16 observers.

The two approaches are surprisingly close. Because the building block (planning factors) approach corresponds more closely to the way the Commission originally developed grade B contour values, the building block numbers are used for the following results:[9]

Grade B service for SHVA determination should require, at least, the following specific signal strength values:

Low VHF	67 dBu
High VHF	72 dBu
UHF	81 dBu

36. In specifying the signal strength criterion, no attempt has been made to deal with ghosting (multipath reflections) because of the variability in cause and severity from one location to the next. An argument could be made that stronger signals are preferred because they offer more opportunity to adjust directional antennas to attenuate the reflected signals. With weak signals a directional antenna may have to be pointed directly at the TV station without any possibility of reorientation. On the other hand, a stronger signal may make the effect of multipathing more pronounced. In any event, as set forth below, ghosting should be taken into account in evaluating, on a case by case basis, whether a household receives a grade B signal even if the signal strength values set forth above are present.

III. Evaluating Whether a Household has Grade B Service

37. Making SHVA determinations by measurement on a household by household basis is clearly impractical. What is needed is a two stage procedure that would allow an initial

[9]Alternatively, if it is desired to emphasize long term reliability and confidence in the outcome the Commission could select the higher of the values in each column.

determination of service by some proxy method, with more detailed techniques reserved for anomalous or contested cases.

38. In first stage, the Commission can use a predictive model to define locations or areas at which it is presumed that the station's signal is adequate or not adequate to provide households with an acceptable picture.

39. Whatever model is used, the locations predicted to be served should fall within the station's "economic service area". The principle of localism cannot justify protecting local stations beyond their economic service area.

40. In the second stage, when a householder disputes the prediction of the model, the householder should be given several choices. For example, without resorting to testing, a household that wants to receive network programming by satellite could agree to pay a monthly fee which would go to the network station and/or network. (This could be implemented whether or not a household can receive a signal of grade B intensity through the use of a conventional rooftop antenna.) While the Commission may not have the authority to decide on a fee, it could recommend such a program to Congress, as the Copyright Office has.

41. Alternatively, the parties could resort to the judgement of an independent local television technician as to whether a particular household is located in an area that does or does not receive acceptable service. This method would allow the effect of ghosting and special problems to be taken into account. The cost would be noticeably less than for taking measurements.

42. Measurements should be the last choice. Measurements are neither simple nor inexpensive, and they are not foolproof or impervious to biases. Further, field strength measurements do not discriminate. The test equipment measures everything intercepted by the

antenna - the desired signal, signal reflections (ghosting), interference and noise. The Commission addressed the problems with measurements in its 1975 Report and Order in Dockets 16004 and 18052. In its decision the Commission refused to permit the submission of measurement data to show the field intensity received at a particular location.

43. If the Commission decides that measurements should be accepted in SHVA determinations, the procedure should:

(1) Be repeatable (verifiable)

(2) Contain an allowance for the variability of signals by both location and time.

(3) Require that measured signals be observed on a TV monitor to detect ghosting or other problems.

(4) Require the cooperation of the affected householder (failure to cooperate results in denial of network programming by satellite).

(5) Specify that signal measurements be made at a height slightly above the rooftop of the subject household, not to exceed 30 feet above ground.

(6) Contain an exemption for those households which cannot employ a rooftop antenna for legal or other compelling reasons.

44. Measurements should be taken as close to the household as possible, probably in the driveway, or the closest point on the street. The measuring vehicle should be moved over a car length, while making measurements, to determine if the signal varies significantly. Measuring antenna orientation cannot be specified in advance; in some cases it should be pointed in the direction of maximum signal strength while in others it may be necessary to point it between television stations.

45. Measuring television field strength is not as simple or common place as holding up a radar gun to check some vehicle's speed. Vans or trucks equipped with 30 foot telescoping

antennas, field strength measuring equipment, and monitors are not readily available in the consumer market. Provision will have to be made for situations when the service of a measuring van cannot be obtained.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge.

William H. Hassinger

Dated: December 10, 1998

4461

RELATIONSHIP OF TELEVISION PICTURE QUALITY TO FIELD INTENSITY

PRESENTED AT
NATIONAL ASSOCIATION OF BROADCASTERS
ENGINEERING CONFERENCE

MARCH 30, 1971

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file

NEIL M. SMITH

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WASHINGTON, D. C. 20036

April 30, 1971

Mr. Harry Fine
Assistant Chief, Research Division
Office of the Chief Engineer
FEDERAL COMMUNICATIONS COMMISSION
1919 M Street, N.W., Room 716
Washington, D. C. 20554

Dear Harry:

Enclosed is a copy of the paper I gave at the recent NAB Engineering Conference, on the subject of television picture quality as a function of field intensity.

As a veteran of many battles on this sort of foolishness, you might at least get a laugh out of it.

Best regards,

Neil

Neil M. Smith

NMS/js

Encl.

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Neil M. Smith

CONTENTS

TABLES

FIGURES

Washington, D. C.

RELATIONSHIP OF TELEVISION PICTURE QUALITY TO FIELD INTENSITY

by

Neil M. Smith

One of the more discouraging traits one can detect in one's fellow man is the tendency to discuss in great detail matters about which that person knows very little. Engineers observe this phenomenon most often when amongst management personnel, of course, but candor requires us to admit to ourselves that engineers are among the worst offenders in this category.

In the world of engineering there are simply too many things to know. This requires us to pick and choose among the possible areas of information available to us in the hope that we will absorb all the knowledge we need without wasting time in unnecessary areas. Moreover, it requires that, in research, we concentrate on certain areas while ignoring others.

In television broadcasting, an area of knowledge about which little is known but much is said is the actual quality of service provided by a station to its public. We have, of course, developed methods of calculating the signal strength expected at particular locations on a statistical basis, and, now and then, the coverage of a station is actually measured. These methods, however, seldom provide us with more than a set of circles on a map, denoting the locations of various median levels of field intensity. Seldom, if ever, do we attempt to depict coverage in terms of the quality of picture made available to the public. In the next few pages, some thoughts on this subject will be discussed.

* * *

We are all familiar with the Grade A and Grade B Service Contours established by the Federal Communications Commission. They are intended to define the reasonable limits of service in urban and rural conditions and are most often based on calculation rather than measurement.

Some years ago the Commission set forth values of field intensity for each of the three television bands, which were considered "required" for adequate service. For Grade A Service, the following assumptions were made:

TABLE 1

BASIS FOR GRADE A SERVICE STANDARD

Required Field Strengths (dbu)
(to overcome receiver noise)

	Channels 2-6	Channels 7-13	Channels 14-83
(1) Thermal Noise	7	7	7
(2) Receiver Noise Figure	12	12	15
(3) Peak Vis. Car./RMS Noise	30	30	30
(4) Transmission Line Loss	1	2	5
(5) Antenna Effective Length	-3	6	8
(6) Local Field Strength	47	57	65
(7) 70% Terrain Factor	4	4	6
(8) 90% Time Fading Factor	3	3	3
(9) Median Field Strength	54	64	74

These calculations are quite simple. The Commission assumed certain receiver characteristics and came up with a value of signal at the receiver input which should provide an acceptable picture. They then threw in a factor for transmission line loss (based on 50 feet of 300 ohm twin-lead) and another that accounted for antenna gain and efficiency (assuming 0 db gain at VHF and 8 db gain at UHF). Finally, they added factors to account statistically for time and location variations and came up with a set of median values of "required" signal strength.

One further step was then made by assuming an additional factor required to overcome urban noise. The addition of this factor resulted in specified Grade A field strengths of 68 dbu for Channels 2-6, 71 dbu for Channels 7-13, and 74 dbu for Channels 14-83. It may be seen that the additional factor was 14 db on Channels 2-6 and 7 db on Channels 7-13, but, at UHF, urban noise was not considered significant, and no additional factor was included.

In similar fashion, "required" rural field strengths were established as follows:

TABLE 2

BASIS FOR GRADE B SERVICE STANDARD

Required Field Strengths (dbu)
(to overcome receiver noise)

	Channels 2-6	Channels 7-13	Channels 14-83
(1) Thermal Noise	7	7	7
(2) Receiver Noise Figure	12	12	15
(3) Peak Vis. Car./RMS Noise	30	30	30
(4) Transmission Line Loss	1	2	5
(5) Antenna Effective Length	-9	0	3
(6) Local Field Intensity	41	51	60
(7) 50% Terrain Factor	0	0	0
(8) 90% Time Fading Factor	6	5	4
(9) Median Field Intensity	47	56	64

In these computations, the same noise and line loss figures were employed, but the antenna factor was changed so as to be based on an antenna of 6 db gain for VHF and 13 db gain for UHF. In addition, different terrain and time fading factors were used, and, of course, urban noise was not considered.

On this basis, the television industry was provided with a standard for service, and the Commission regularly employs these standards in its determinations. Popularly, the Grade B Contour is considered the limit of reasonably *usable* service, while the Grade A Contour is taken to define the limit of *good* service. The City Grade Contour, established simply as 6 db above the Grade A level in all cases, is usually thought of as defining *high quality* service.

Through use, these standards have become reasonably well understood, and they provide a convenient basis for comparisons between one station and another. The question remains, however: Are these standards reasonably representative of actual conditions in the viewers' homes?

*   *   *

It is not difficult to design a program of measurement and observation by which an answer to this question can be found. The only difficulty lies in the time and expense necessary to obtain sufficient information for analysis, which is the main reason for the paucity of data in this area.

Despite these problems, there is, from time to time, reason to make such studies for specific purposes, and the data thus obtained can sometimes be used to answer questions concerning the general nature of television service.

The writer has participated in a number of studies of this nature, involving measurements and observations on stations in various locations and on differing frequencies. Of these studies, one was particularly appropriate to the present question, and the data included herein is taken from that study.

In this measurement program, data was obtained on a low-band VHF station, a high-band VHF station, and a UHF station, all serving the same area. Field intensity and picture quality information for each station was taken at a total of 203 locations covering a wide range of field intensity and picture quality.

The equipment employed is shown in the block diagram in FIGURE 1 and in the photographs in FIGURE 2. The antenna was a Jerrold Model VU-832 which is designed for both VHF and UHF reception. It was purchased from a major Jerrold dealer who recommended it as representative of the all-channel antennas being installed by him in that specific locality. For each channel, the Jerrold antenna was calibrated against the appropriate standard dipole.

The antenna was connected through a balun and coaxial transmission line to a coaxial switch, by which the signal could be fed to either of two field intensity meters or to an RCA Model AL006W television receiver designed to operate from a 12-volt DC power source. (This receiver was purchased, new, at the beginning of the study.) An opaque tunnel was attached to the front of the receiver, through which photographs of the television screen could be taken.

The two field intensity meters were an RCA Model BW-3A (for UHF) and a Nems-Clarke Model 107-A (for VHF). By means of a switch, the output of either meter could be used to drive an Esterline-Angus Model A-601-C chart recorder.

All of the equipment was housed in a small van which included a pneumatically operated telescoping mast to permit measurement at an antenna height of 30 feet above ground.

At each location selected, the mast was raised to its full height, and one of the field meters was tuned to the appropriate channel. The antenna was then oriented for maximum signal, the meter calibrated, and a mobile run of 100 to 200 feet was recorded. (In many cases, a 10-db pad was inserted into the input of the field intensity meter so as to permit measurement near mid-scale on the meter.) The truck was then returned to a location on the path just traversed at which a signal of approximately median value was obtained. At that location, the signal was fed to the RCA television receiver, the receiver tuned, the photograph taken, and the picture quality grade established.

This technique was followed for each of the channels at each of the 203 locations. After all data was obtained for one location, the mast was lowered, field notes were completed, and the vehicle was then driven to the next location.

In grading the pictures, the six-grade TASO system was employed, which is similar to other systems often used for this purpose. The grades are assigned numbers, 1 through 6, and were described in the TASO Report as follows (See FIGURE 3.):

TABLE 3

TASO PICTURE QUALITY GRADES

GRADE 1 (Excellent) - The picture is of extremely high quality; as good as you could desire.

GRADE 2 (Good) - The picture is of high quality, providing enjoyable viewing. Interference is perceptible.

GRADE 3 (Passable) - The picture is of acceptable quality. Interference is not objectionable.

GRADE 4 (Marginal) - The picture is poor in quality, and you wish you could improve it. Interference is somewhat objectionable.

GRADE 5 (Inferior) - The picture is very poor, but you could watch it. Definitely objectionable interference is present.

GRADE 6 (Unusable) - The picture is so bad that you could not watch it.

By these means the measured field intensity and the resultant picture quality were obtained for a station in each of the three television bands at each of 203 separate locations. These data may be analyzed in a number of ways.

In FIGURE 4, the data is plotted as a function of probability for the three stations; that is, the data was separated by picture quality, and all of the measured field intensity values for each particular grade of picture were plotted against probability. These data show some interesting effects.

We see, as one would expect, that higher quality pictures tend to be associated with higher values of field intensity. We also see, however, that there is considerable overlapping of data points. This tabulation is taken from these graphs:

TABLE 4

MEDIAN FIELD INTENSITY BY PICTURE GRADES

Picture Grade	Measured Field Intensity (dbu) Low-band VHF Median	Range	High-band VHF Median	Range	UHF Median	Range
1	78	48-103	99	71-122	97	79-109
2	74	51-106	87	66-115	92	75-106
3	59	38--77	69	58--97	75	58--88
4	54	30--83	59	51-105	65	56--88
5	47	21--65	49	33--80	62	40--89

Thus we see that although the median value of field intensity increases as picture quality improves, there is a wide spread in the data. The greatest spreads were found for low-band VHF, with the values of field intensity for a given level of picture quality covering a spread of some 50 db. The variations on high-band VHF were slightly less, on the average, and the spreads at UHF were much less, being on the order of 30 db.

At low-band VHF, the differences in slope from one set of data to another are much greater than those found in any other band. As a matter of fact, the curves (lines) intersect. This should mean that, for instance, in low-band VHF, with fields higher than 95 dbu, there are more Grade 2 pictures than Grade 1 pictures. Or, for the same band, with a signal stronger than 64 dbu, more Grade 4 pictures than Grade 3 pictures are observed.

One's reason says that these things cannot be and that, therefore, there is perhaps an insufficiency of data. On the other hand, the results are not surprising, if one remembers that a great portion of the rating of picture quality in this study involved ghosting, and ghosting is independent of signal strength. Thus, it is likely that what the data really says is that, once a particular level of signal is reached, picture quality is affected predominantly by other factors. Therefore, for the low-band VHF Grade 1 and 2 data, it seems more nearly correct to conclude that, when the field intensity exceeds approximately 85 dbu, the grade of picture will depend on the extent of ghosting, and that a curve based solely on signal strength becomes meaningless at that point.

Although these plots provide certain information, their practical value is actually quite limited. They tell us what the field intensity is likely to be for a picture of a given quality, but they do not help us to anticipate the picture quality when field intensity is known, which is most often the case and which is the basic concern herein. In order to provide such information, the data has been reanalyzed, resulting in the rather unorthodox graphs in FIGURE 5.

In the construction of these graphs, the data was first separated by frequency band and then by field intensity "blocks." By this we mean that all picture quality data corresponding to field intensities between, say, 90.0 dbu and 94.9 dbu was grouped together, and the percentages of each quality level established. By plotting this data it was possible to establish the smooth curves shown.

The vertical scale is field intensity in dbu. The horizontal scale is 100 units of percentage. If one selects a given level of signal strength, one can find the distribution of picture quality levels that would be expected for signals of that strength. For example, on low-band VHF, at the Grade A signal level (68 dbu), there are 38 percentage units in the Grade 1 area of the graph, 43 units in the Grade 2 area, 11 units in the Grade 3 area, and 6 units in the Grade 4 area. This means that (where conditions are identical to those existing during the subject study, of course) for a signal of 68 dbu on low-band VHF, 38 per cent of the locations would receive a Grade 1 picture, 43 per cent would receive a Grade 2 picture, 11 per cent would receive a Grade 3 picture, 6 per cent would receive a Grade 4 picture, and the remaining 2 per cent would receive either a Grade 5 or a Grade 6 picture. (When analyzing data on the basis of probability, it is, of course, impossible to arrive at a 100 per cent figure, since an element of uncertainty must always exist. Thus, the graph does not extend across the entire horizontal scale, and the percentage figures nearer the ends of the scale are rather imprecise.)

These graphs may be used and compared in a number of ways. They show us that distinct differences exist from one frequency band to another, and that the relationship between field intensity and picture quality is not at all linear. To receive a usable picture--that is, Grade 5 or better--at 50 per cent of the locations, 34 dbu is required at low-band VHF, 40 dbu is necessary at high-band VHF, and 53 dbu is required at UHF. Similarly, for a perfect (Grade 1) picture at 50 per cent of the locations, 76 dbu is required at low-band VHF, while approximately 95 dbu is required for such quality at high-band VHF or UHF.

At the Grade B level, the following was found:

TABLE 5

DISTRIBUTION OF PICTURE QUALITY GRADES
AT GRADE B CONTOUR

Picture Grade	Percentage of Each Picture Grade Low-band VHF	High-band VHF	UHF
1	5	<1	<1
2	4	<1	<1
3	20	5	10
4	22	69	28
5	42	23	39
6	7	3	23

These data show that if one assumes that a Grade 4 picture is the poorest quality to be considered usable (Grade 5 being unacceptable for viewing by most people), the Grade B specification for low-band VHF is quite suitable, since 51 per cent of the Grade B locations would receive at least a Grade 4 picture. For high-band VHF, 74 per cent would be so served at that signal level, but at UHF, only 38 per cent would receive a usable picture.

At high-band VHF and UHF, no appreciable number of Grade 1 or 2 pictures are found at the Grade B contour, but 9 per cent of the low-band VHF pictures are in those grades at that level of signal. On the other hand, there are more Grade 6 pictures at low-band VHF than at high-band VHF, and many more at UHF.

One of the interesting points found in the graphs is that, for high-band VHF, the curves defining the upper limits of Grades 3, 4, and 5 have only a slight slope across most of the graph. Although all of the graphs show the greatest uniformity and the least slope in this region, the phenomenon is not nearly so marked for the other bands. What this suggests is that for these values of picture quality, field intensity is vastly the most important factor in picture quality, and the relationship between the two is very nearly linear. Thus it may be seen that, at the Grade B signal level, only 5 per cent of the pictures are of Grade 3 quality, but an increase of 6 db in signal strength would result in Grade 3 pictures at 62 per cent of the locations. As a comparison, it may be seen that, at City Grade level for high-band VHF, 19 per cent of the pictures are of Grade 1 quality, but an identical increase in signal strength of 6 db in this case increases the instances of Grade 1 pictures only to 29 per cent.

Even though the data on which these curves are based is insufficient to establish any great truths about television service, the phenomenon just observed forces the conclusion that an improvement in received field intensity provides picture quality improvement most noticeably where middle grade pictures are found, and a much greater increase in signal strength is required to provide significant improvement for the highest and lowest grades of pictures. In other words, a power increase would convert a great many Grade 4 pictures into Grade 3 pictures, but the Grade 6 pictures turned into Grade 5 pictures would be many less in number, as would the Grade 2 pictures that improved into Grade 1.

This effect is quite logical. The observable difference between Grade 1 and Grade 2 pictures is very often in the presence of a slight ghost. Such a ghost would probably not be noticed in the noisier Grade 3 and 4 pictures. On the other hand, the difference between Grade 5 and 6 pictures is most often a function of the ambient noise level at the particular receiving location, while, for Grade 3 and 4 pictures, the differences in noise level from location to location are not so noticeable. Thus, signal strength is most important where medium grade pictures are received.

*   *   *

From these curves, one could establish a set of coverage contours, different from those now employed, that would relate more directly to the quality of picture received. The standards might be as follows:

GRADE B: Grade 4 picture cr better at 50% of the locations

GRADE A: Grade 2 picture or better at 50% of the locations

CITY GRADE: Grade 1 picture at 50% of the locations

The field intensity values for such standards (with the present values included as a reference) would be:

TABLE 6

SUGGESTED SERVICE STANDARDS

	Field Intensity (dbu)					
	City Grade		Grade A		Grade B	
Band	Present	Suggested	Present	Suggested	Present	Suggested
Low VHF	74	76	68	60	47	47
High VHF	77	94	71	68	56	54
UHF	80	95	74	79	64	68

There are two significant points to be made from this table. In the first place, the general similarities are quite striking. In seven of the nine sets of figures, the present and suggested values differ by no more than 8 db, suggesting that the Commission's standards do indeed illustrate reasonably comparable levels of service. The other matter of importance is that, for City Grade service on high-band VHF and UHF, the present standards are optimistic by 15 db or more. This means that for excellent pictures at these frequencies much more signal is required than had previously been assumed.

But why should the City Grade level for low-band VHF agree so well with the level required for Grade 1 pictures?

The answer is simple. A substantial factor for the effects of urban noise on low-band VHF reception is included in the City Grade specification, but such noise is only significant in the more industrialized portions of a city and has little effect in the outlying residential areas. Thus, this disadvantage is realized in only a small percentage of the locations and tends to show its effects mainly by introducing additional scatter in the low-band VHF data.

* * *

It thus would appear that the above data should provide a very practical means of defining television coverage. However, before such a conclusion can be reached, a number of doubts must be resolved:

TABLE 7

QUESTIONS REGARDING VALIDITY OF SURVEY DATA

1. How accurate is the field intensity data?
2. How accurate are the corresponding picture quality ratings?

3. To what extent is the data sufficient for detailed analysis?

4. Are the measured stations representative of all stations?

5. Is the locality representative of all localities?

6. Is the receiving installation representative of all receiving installations?

Points 1 and 2 present few problems. The measurements were based on the well established TASO technique, and the instruments were calibrated by the National Bureau of Standards. Although the picture quality determinations are a more subjective sort of thing, in this particular case the screen was photographed for each channel at each location so that others could use the photographs for independent evaluation. In all cases, although all observers did not agree on all pictures, the overall ratings were remarkably similar, suggesting that the picture quality ratings were not unduly influenced by a single viewer's idiosyncrasies.

The third point is a significant one. Based on 609 observations at 203 locations, the data is insufficient for any real generalizations, particularly with regard to the middle grades of pictures. If the subject study had been designed expressly for the purposes of this discussion, much more data on middle grade pictures would have been obtained, and much less data on Grade 6 pictures would have been accumulated, since it is worth little in this discussion.

With regard to the particular stations and the particular locations studied, there is no reason to believe that these are not representative of all stations and localities, but one could not be sure of this without obtaining at least some similar data on other stations in other places. These questions must therefore be left unanswered.

The sixth question is the most important. The receiving installation is made up of an antenna, a transmission line, and a receiver. In order that the test results be as representative as possible, a number of different receivers should be tested, even though the receiver employed in the subject survey is believed to be reasonably representative of the television sets presently on the market. Furthermore, all observations in the subject study were of a monochrome picture, and data based on color pictures would be a valuable addition (although it is the author's experience that there is seldom a serious statistical difference between monochrome and color quality ratings).

The transmission line is a minor matter, and differences in line from one installation to another are a relatively small factor; however, the antenna used is of great significance, and this is the most critical factor in extrapolating this specific data into the realm of the general.

It has already been pointed out that the antenna was represented to by typical of those in use in the area studied. Its characteristics, however, are not the same as those assumed in the establishment of the Grade A and B signal strengths. The gain figures are as follows:

TABLE 8

COMPARISON OF ANTENNA GAINS

Band	Antenna Gain (db) Assumed by FCC	Antenna Gain (db) Used in Survey
Low-VHF	0 (city), 6 (rural)	2
High-VHF	0 (city), 6 (rural)	7.5
UHF	8 (city), 13 (rural)	7

It may be seen that the gain figures assumed by the FCC do not agree very well with the gain figures of the antenna employed in the subject survey. In urban areas, the Commission assumed the use of rabbit ears, or the equivalent, for VHF and an antenna gain of 8 db for UHF. For rural areas it was assumed that VHF antennas would have a gain of 6 db, with 13 db gain assumed for UHF antennas. The subject antenna had a gain of 2 db at low-VHF and approximately 7 db a high-VHF and UHF. Is either set of figures realistic in terms of present usage?

In urban areas, rabbit ears are commonly used for VHF reception, particularly for the second and third sets in a home. In such instances, however, a UHF loop antenna is usually used, so the assumption of 8 db gain would seem optimistic. Where an outside antenna is employed, it is either an all-channel antenna similar to that used herein, or it is designed for VHF only.

Thus, in a city, when indoor antennas are used, the Commission's assumptions are reasonable for VHF but seem optimistic for UHF. Where outside antennas are installed, the assumptions are reasonable for low-VHF and UHF, but not for high-VHF. [It should be pointed out that, with all-channel antennas, while the size of the antenna (and, consequently, its gain) may vary, the relationships of the gain figures for the three bands tend to remain similar to those shown above, with high-VHF and UHF gains similar (except for the very highest UHF channels) and low-VHF gain several db less.] In rural areas, the Commission appears to have been optimistic about low-VHF and UHF gain, but reasonably correct for high-VHF.

It is therefore difficult to resolve the last question. The author, as you might expect, believes that the gain of the antenna used is more typical than the gain figures assumed by the FCC. One may, however, believe that the Commission's assumptions, or some other assumptions, would be more appropriate and still make use of the curves included in this report by shifting the horizontal scale so as to correct for the difference in assumed gain. For example, if a UHF antenna of 13 db gain is assumed for rural areas, one need simply refer to the 70 dbu line on that graph (64 dbu + 6 db) to establish the expected picture quality percentages at the Grade B Contour. (This process, of course, does not account for changes in ghosting resulting from the use of a higher or lower gain antenna.)

* * *

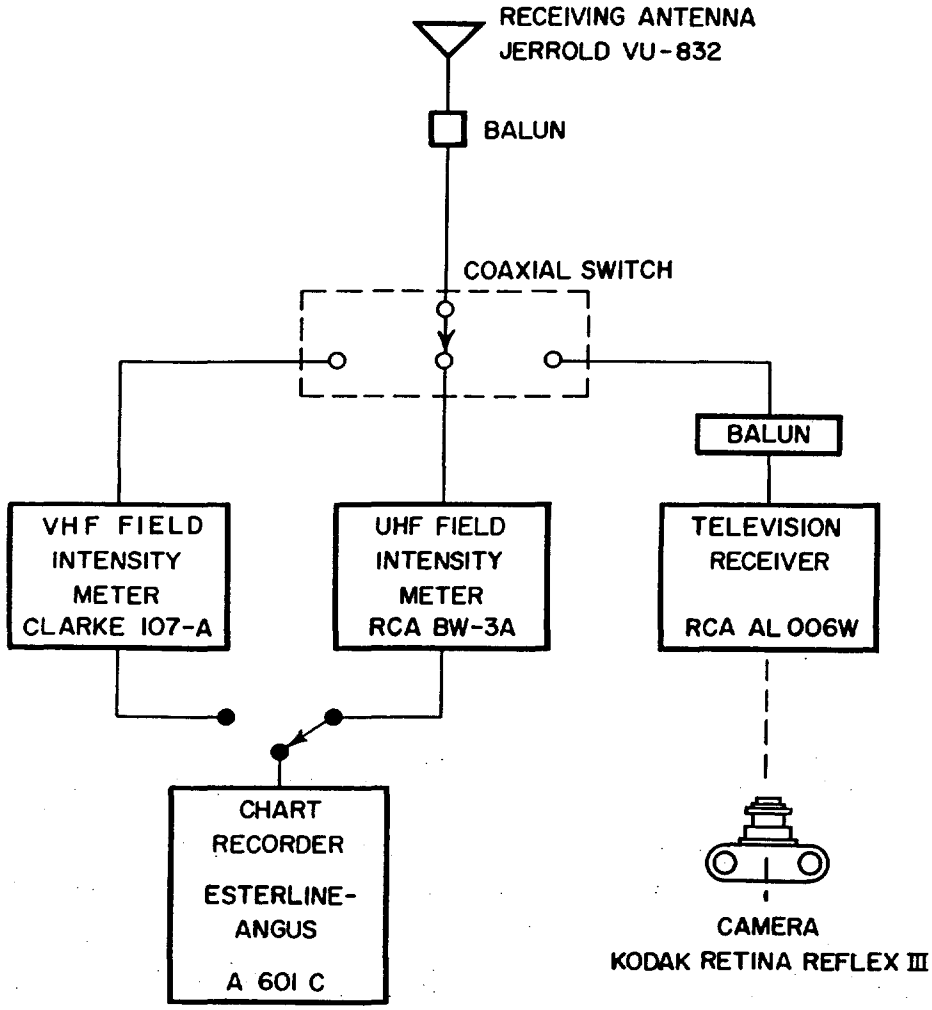
If one is to utilize these curves, it is important to remember that they represent a comparison of *measured* field intensity and picture quality. These picture quality ratings would compare to *predicted* field intensity only if the predicted values were actually achieved, and this is often not the case, particularly in the UHF band. Thus, these curves should be used with the understanding that, if the predictions of received field intensity are not correct, the picture quality provided also will not agree with the prediction.

* * *

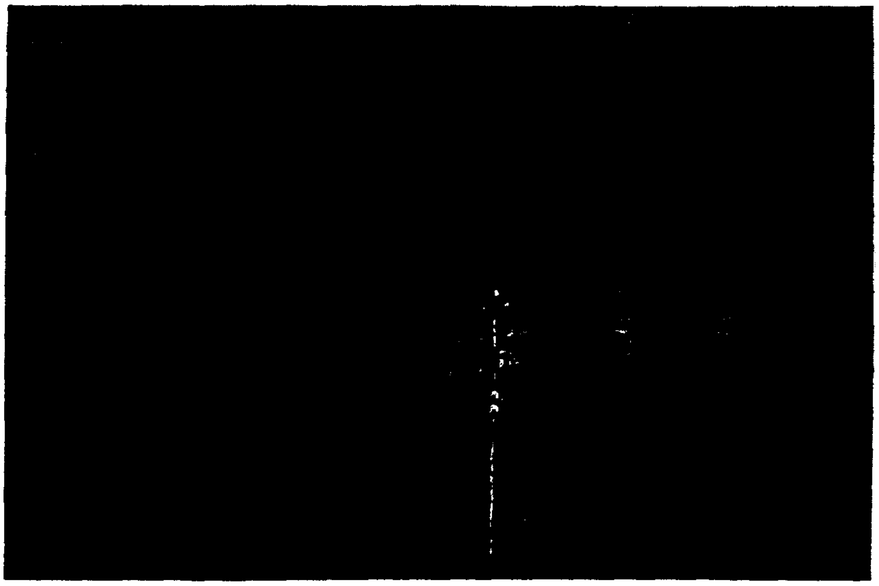
Based on the above, we may conclude that we have established a set of curves by which one may predict the quality of picture delivered in the viewers' homes, within the limits of accuracy as discussed above. From these curves we may make a number of conclusions about television service, among which are:

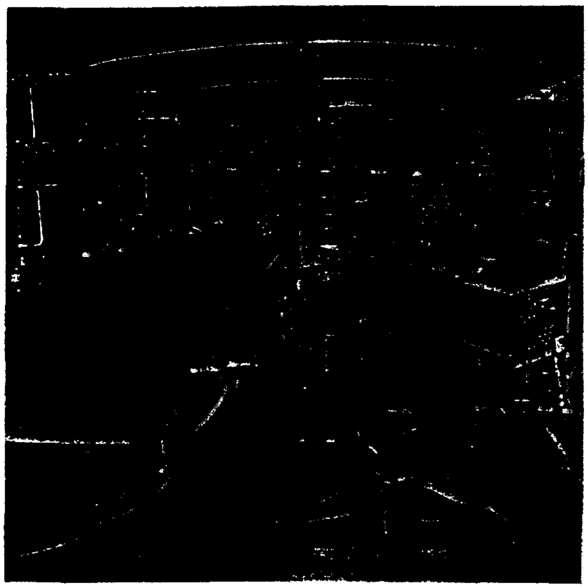
- Changes in signal strength affect middle grade pictures more noticeably than the very good or very bad pictures.
- The relationship between picture quality and field intensity is not at all linear, although it is more so for middle grade pictures and for high-band VHF.
- The optimistic assumptions about UHF antenna gains seem to have resulted in somewhat optimistic UHF contour values.
- The pessimistic assumptions about urban noise seem to have resulted in a pessimistic low-band VHF Grade A standard.
- Even though the current FCC contour value standards are far from precise, in a general sense, and as thought of in day-to-day usage, these standards do provide a realistic picture of station coverage.

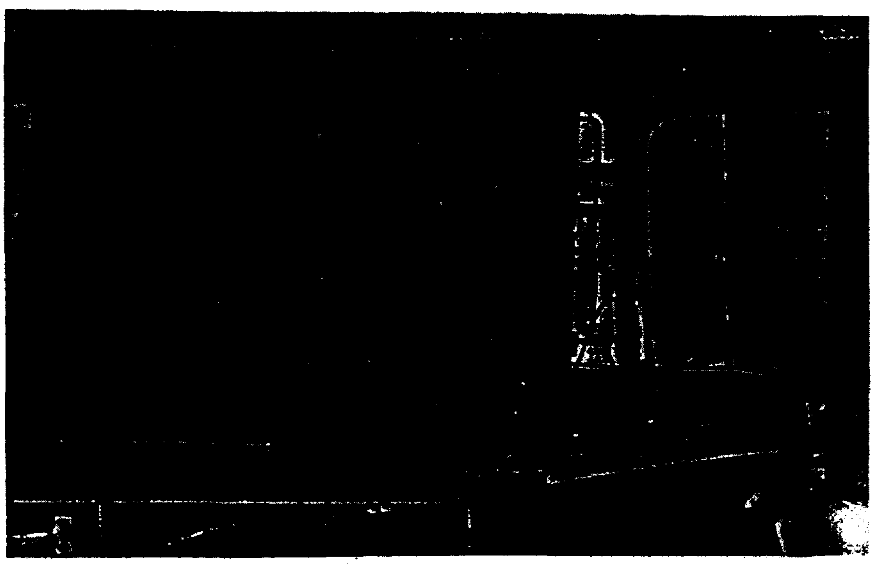
FIGURES



EQUIPMENT SET-UP







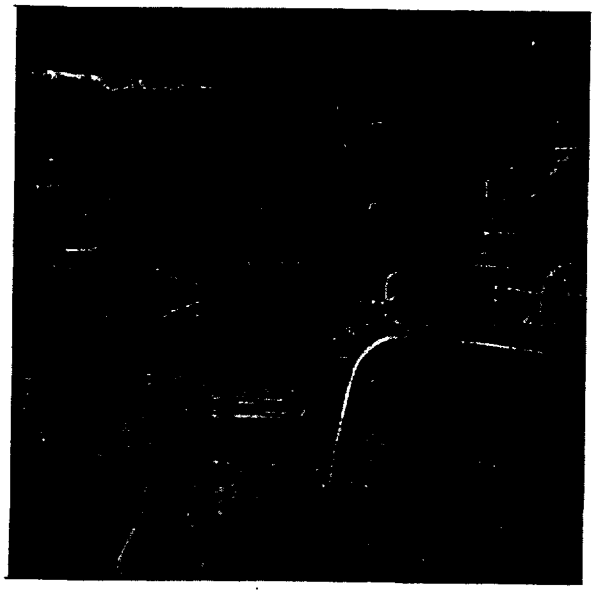
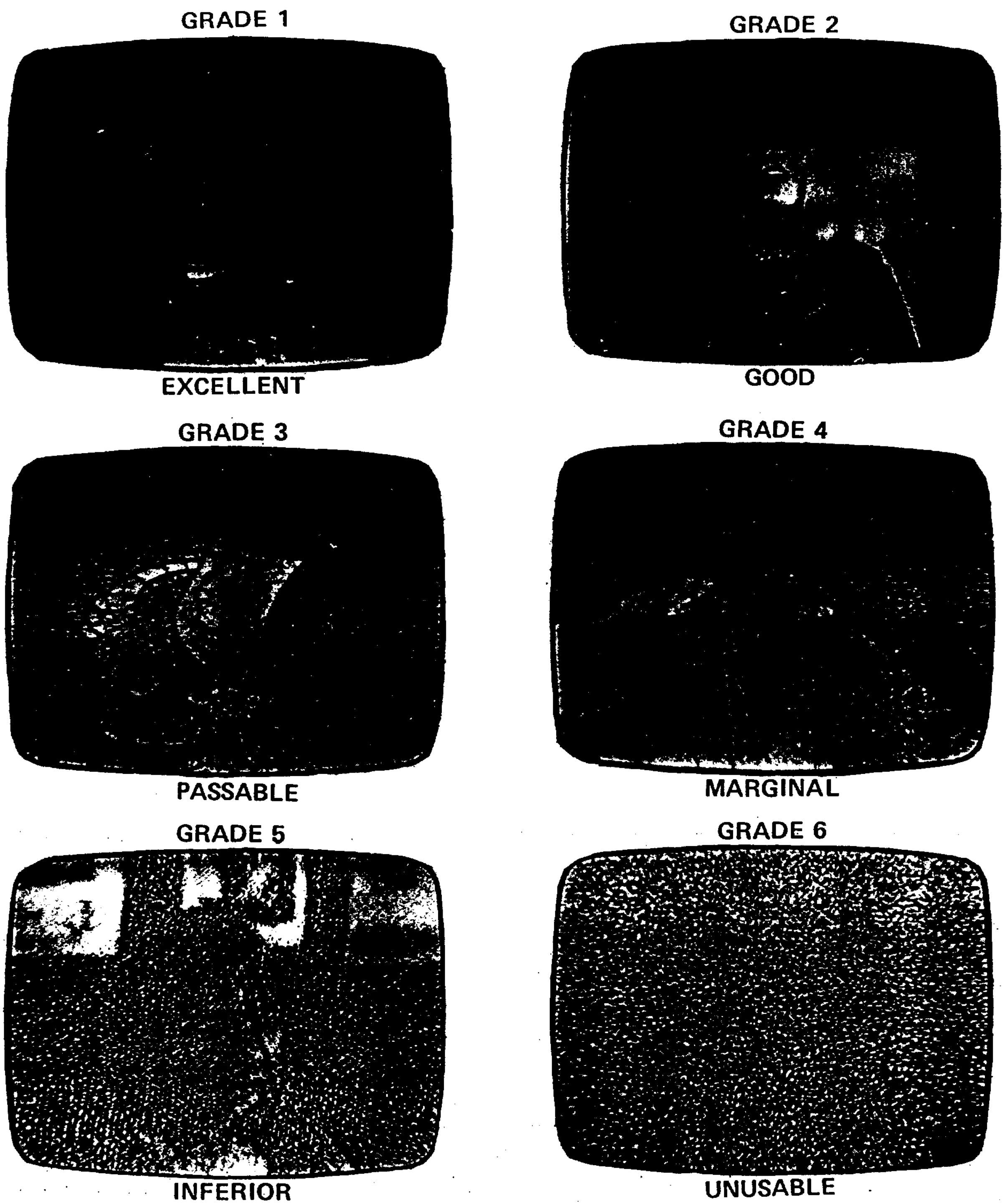
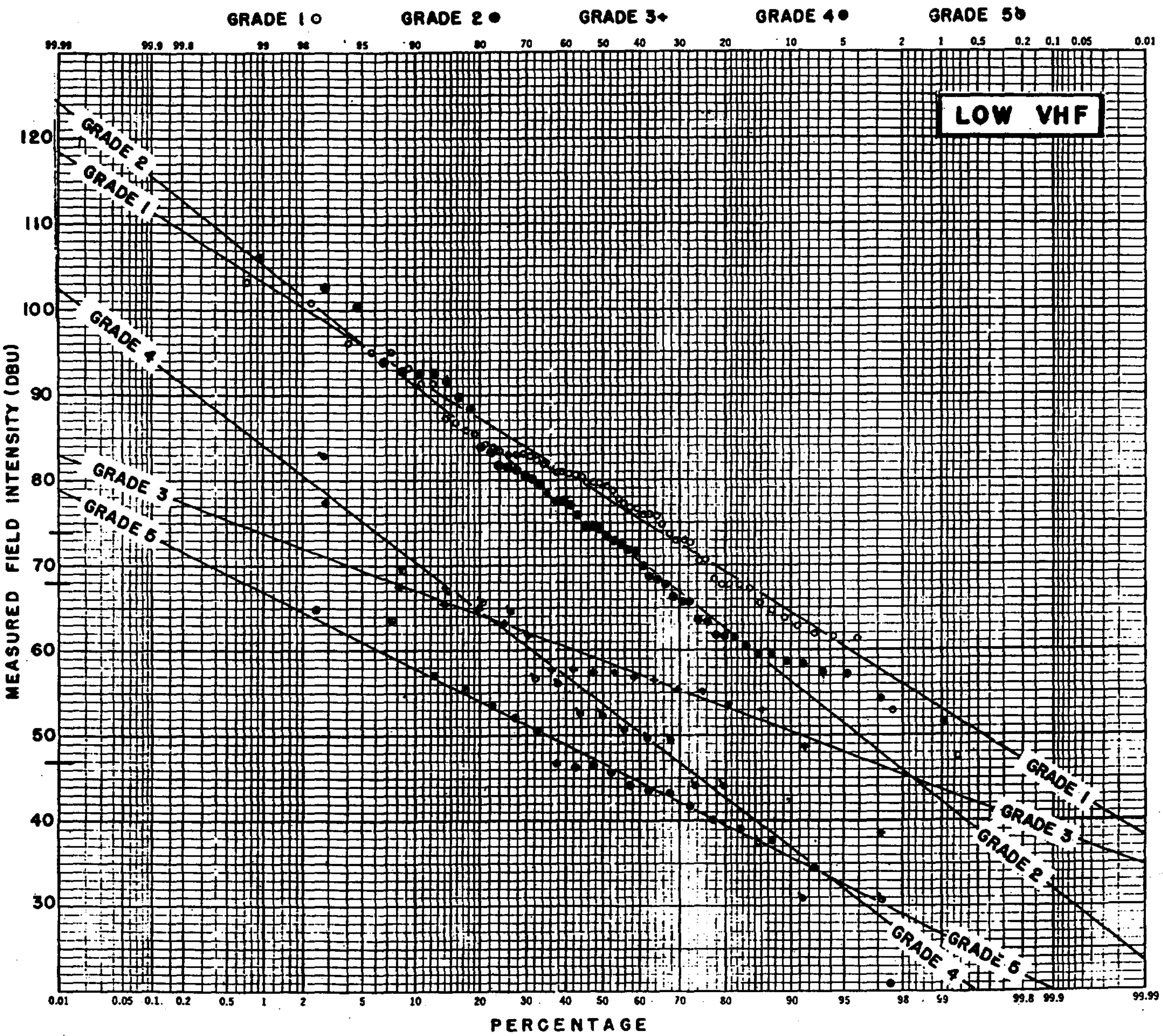
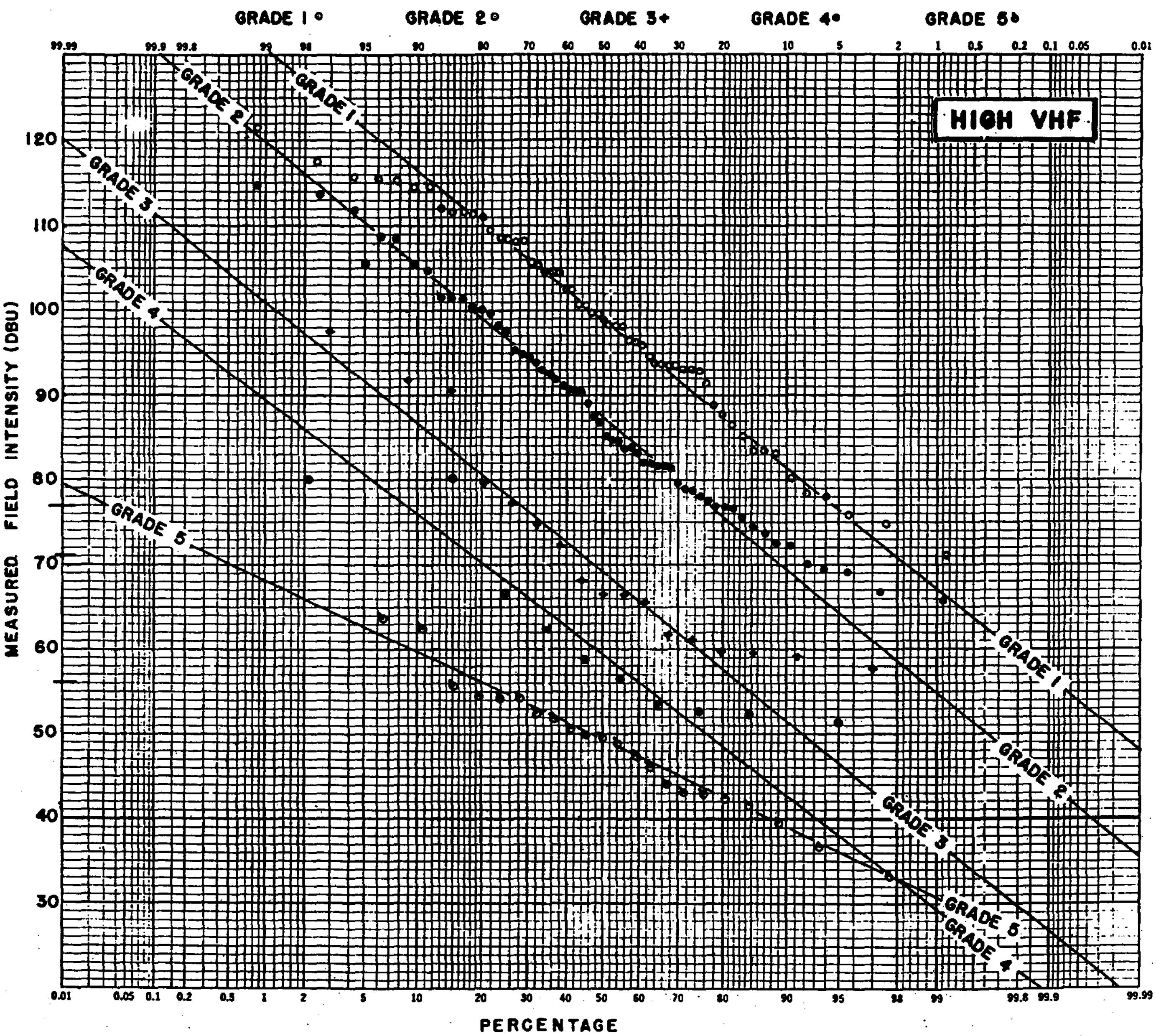


FIGURE 3



EXAMPLES OF TASO PICTURE
QUALITY GRADES


GRADE 1 ○
GRADE 2 ●
GRADE 3 +
GRADE 4 ●
GRADE 5
LOW VHF
GRADE 2
GRADE 1
GRADE 4
GRADE 3
GRADE 5
GRADE 1
GRADE 3
GRADE 2
GRADE 5
GRADE 4
MEASURED FIELD INTENSITY (DBU)
PERCENTAGE


GRADE 1 ○ GRADE 2 ○ GRADE 3 + GRADE 4 ● GRADE 5 ●
HIGH VHF
GRADE 1
GRADE 2
GRADE 3
GRADE 4
GRADE 5
MEASURED FIELD INTENSITY (DBU)
PERCENTAGE

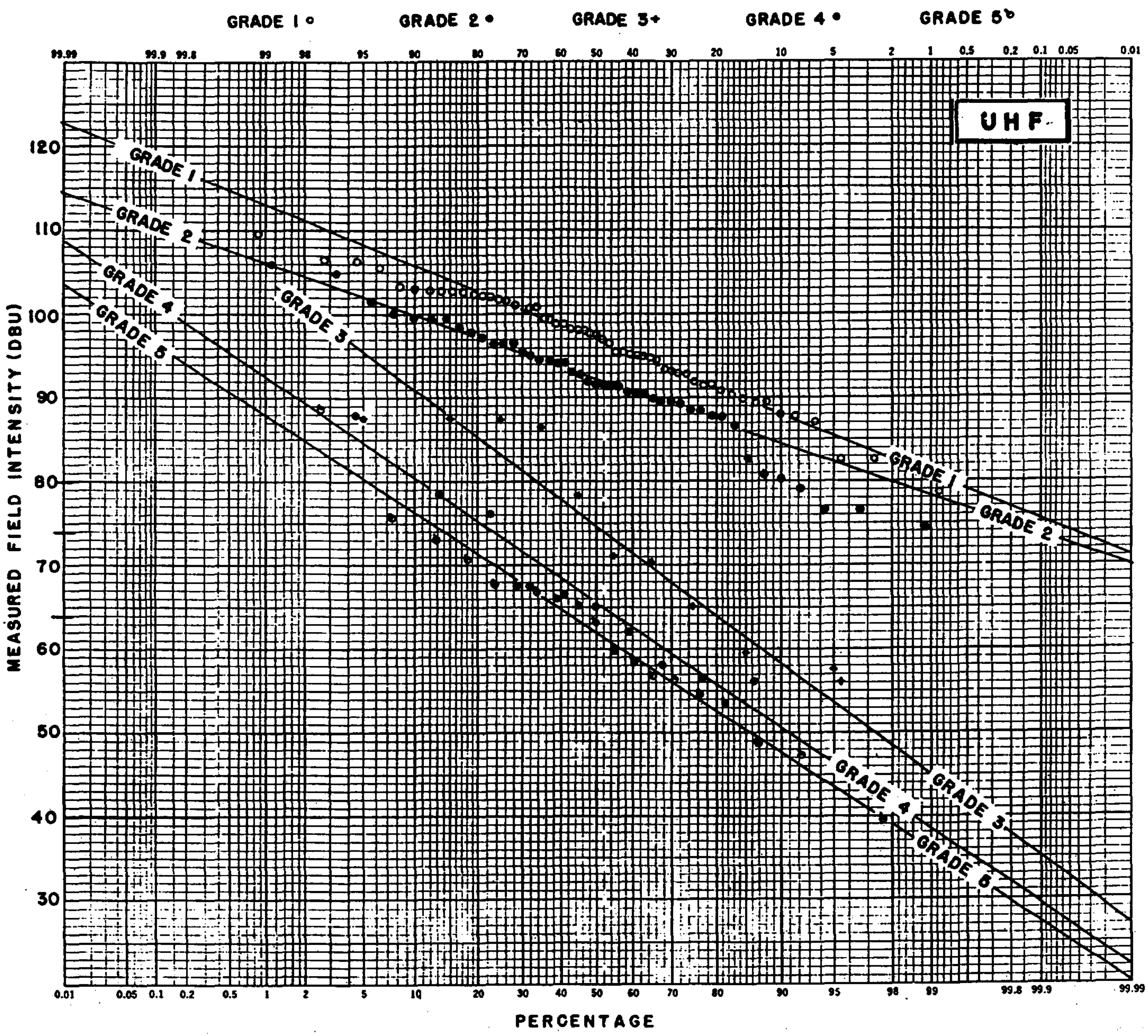

GRADE 1 ○
GRADE 2 ●
GRADE 3 +
GRADE 4 ●
GRADE 5
UHF
GRADE 1
GRADE 2
GRADE 3
GRADE 4
GRADE 5
MEASURED FIELD INTENSITY (DBU)
120
110
100
90
80
70
60
50
40
30
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
99.9
99.99
PERCENTAGE

FIGURE 5

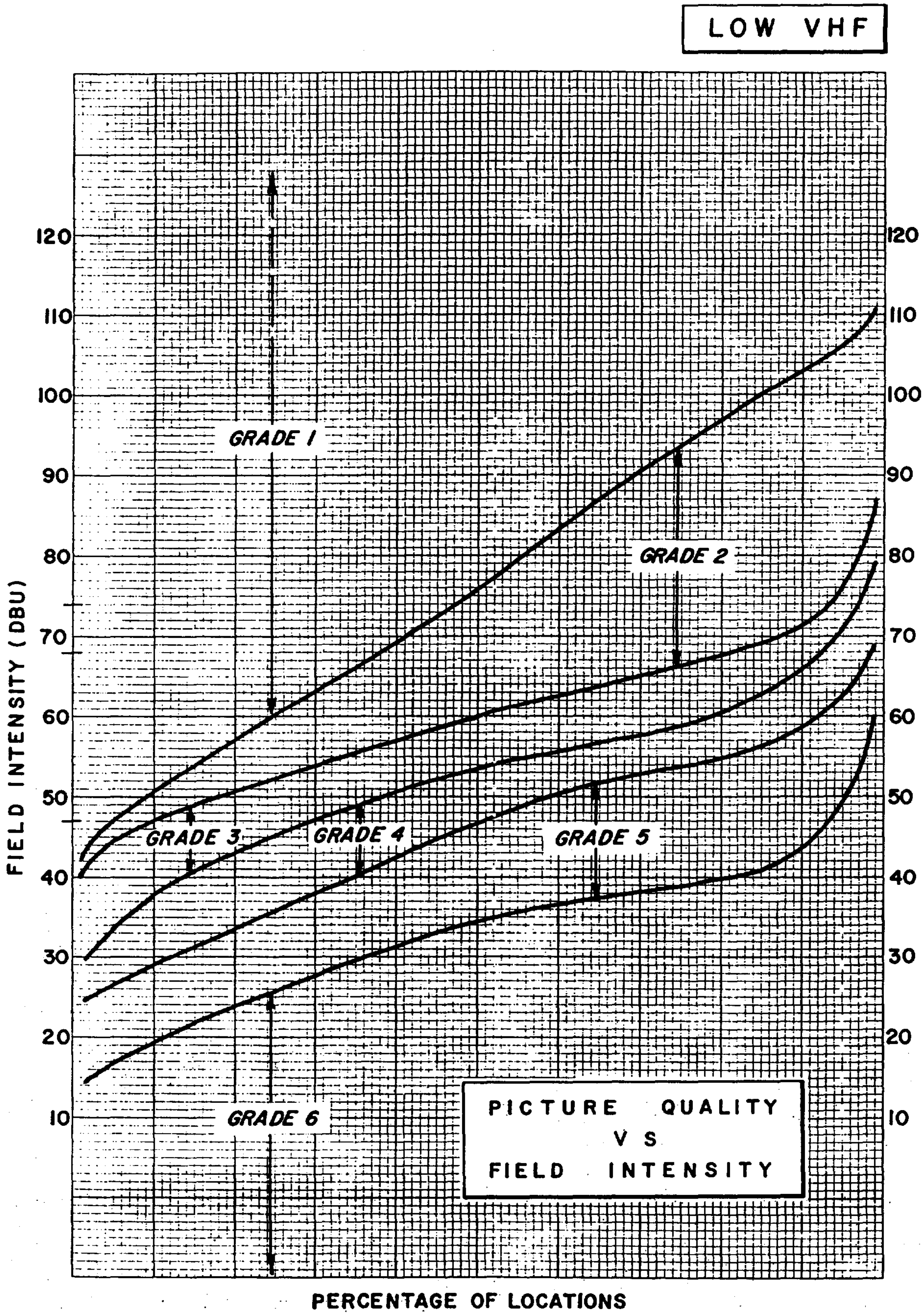
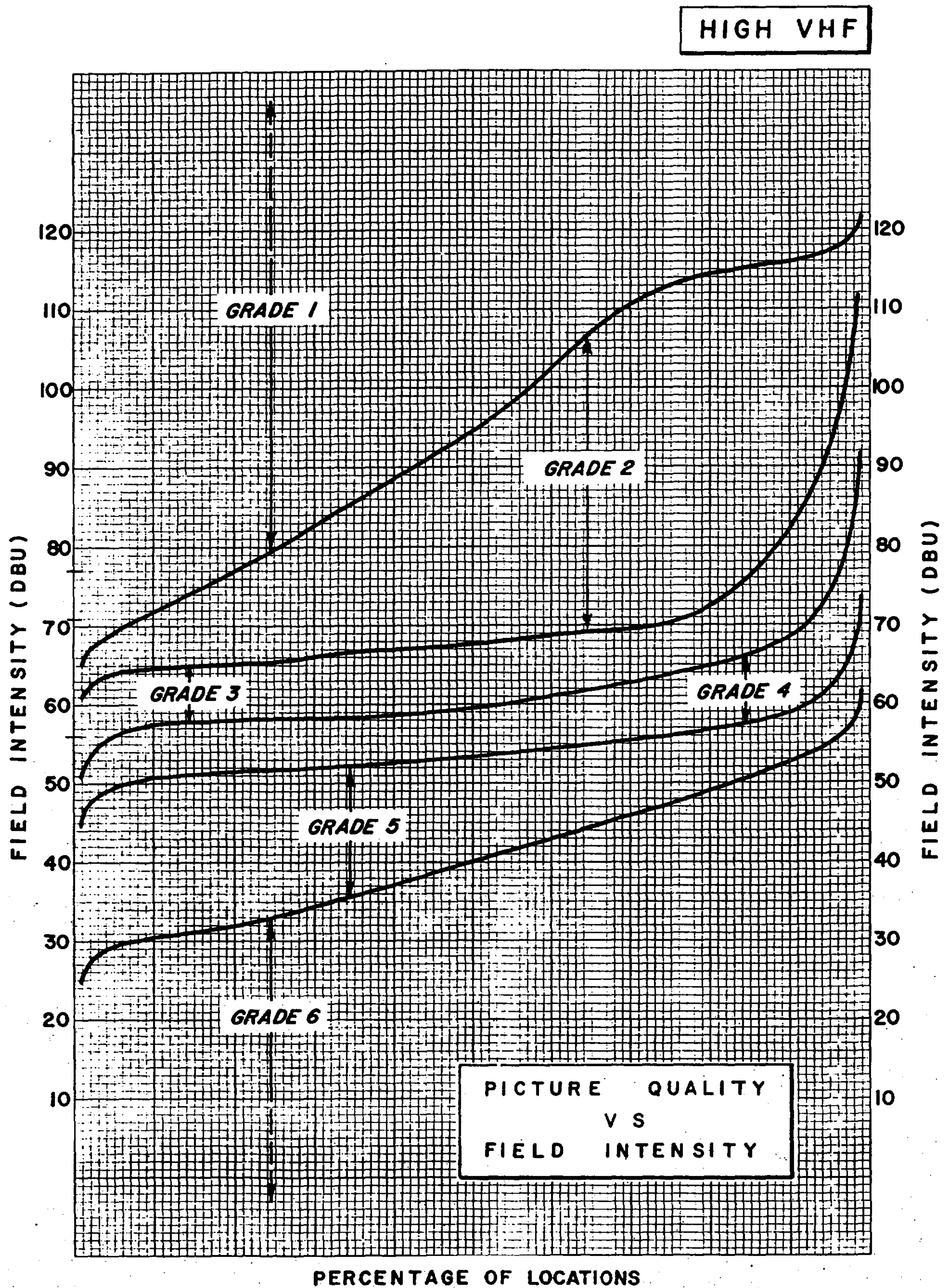

LOW VHF
120
110
100
90
80
70
60
50
40
30
20
10
FIELD INTENSITY (DBU)
GRADE 1
GRADE 2
GRADE 3
GRADE 4
GRADE 5
GRADE 6
PICTURE QUALITY
VS
FIELD INTENSITY
PERCENTAGE OF LOCATIONS

FIGURE 5-B


HIGH VHF
GRADE 1
GRADE 2
GRADE 3
GRADE 4
GRADE 5
GRADE 6
FIELD INTENSITY (DBU)
FIELD INTENSITY (DBU)
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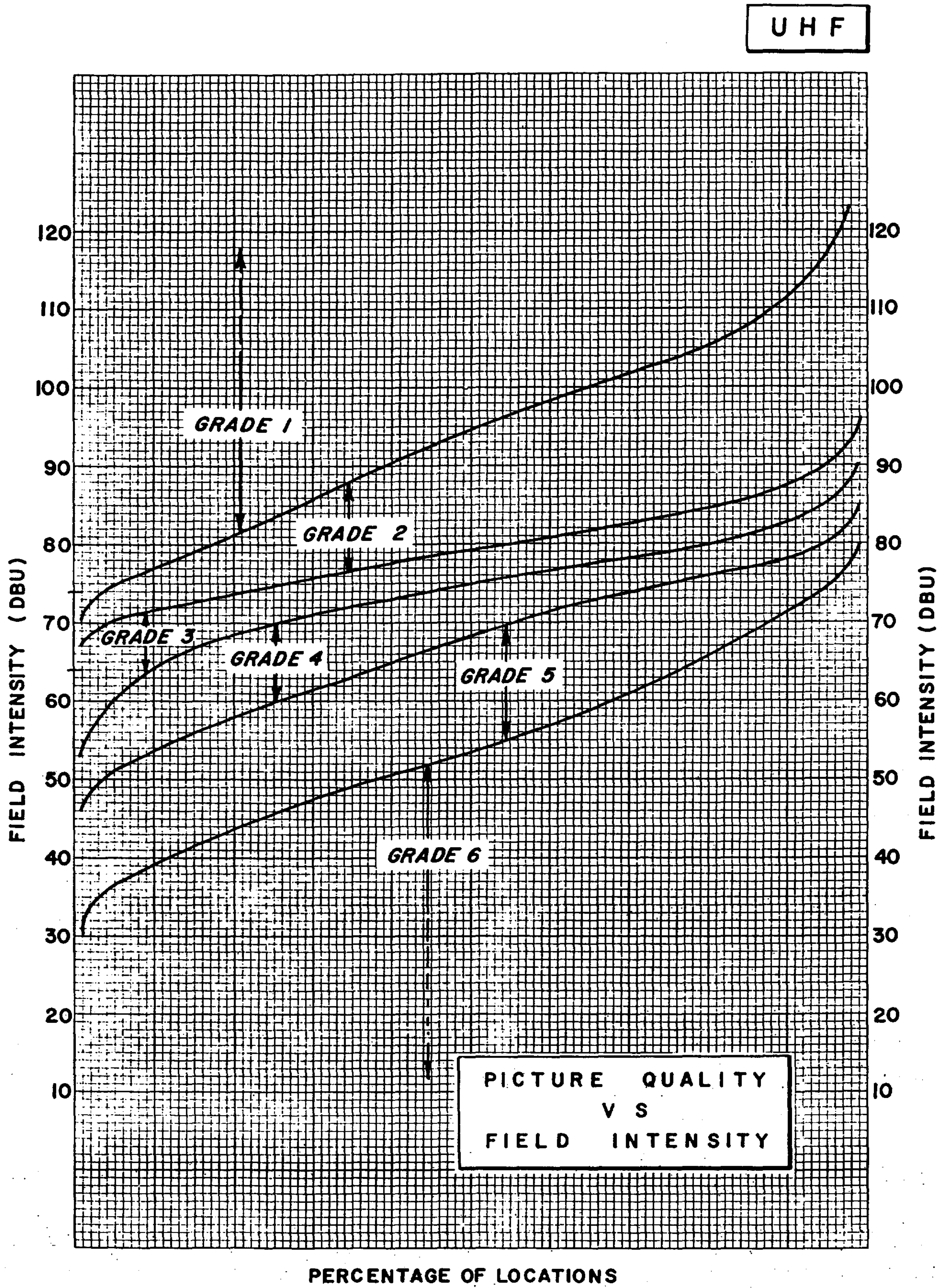
110
100
90
80
70
60
50
40
30
20
10
PICTURE QUALITY
VS
FIELD INTENSITY
PERCENTAGE OF LOCATIONS


UHF
120
110
100
90
80
70
60
50
40
30
20
10
FIELD INTENSITY (DBU)
GRADE 1
GRADE 2
GRADE 3
GRADE 4
GRADE 5
GRADE 6
PICTURE QUALITY
VS
FIELD INTENSITY
PERCENTAGE OF LOCATIONS